not accompanied by a considerable fall of rain" (Loomis's eighth paper).

As early as 1876 Hann found, from the observations on the alpine peaks, that the highest temperature in the upper air occurred with the highest pressure, and explained it as due to the dynamic heating of descending air.

In 1886 Dechevrens showed that on the European peaks Pic du Midi and Puy de Dome, and on Pike's Peak in the United States, the lowest temperature occurred with the lowest pressure, which was exactly the opposite of observations at sea level. He also gave an example of simultaneous observations at the base and summit of the Puy de Dome during a low and during a high pressure, as shown by the barometer at both stations. At the base the temperature was highest with the low pressure, but at the summit the lowest pressure and temperature occurred together (*American Meteorological Journal*, August, 1886).

In the *American Meteorological Journal* for May, 1886, Mr. Dewey stated that from thirty-four pairs of observations during the winter months of 1872 and 1873 he found the average difference of temperature between Burlington, Vt., and the top of Mount Washington to be 6.6° F. when the latter was within a hundred miles of the centre of an anticyclone. The normal difference between the two stations is 19°. In the different quadrants of the anticyclone he found the following differences: north, 9°; east, .0°; south, 4.5°; west, 12.2°; average, 9°. He found the average difference two degrees greater in cyclones. Hazen's results for Mount Washington and Burlington, however, differ from these (*American Meteorological Journal*, October, 1887), so that further comparisons are needed.

In a footnote to an article on the origin and development of storms in the *American Meteorological Journal*, September, 1886, I cited the following reasons for thinking that warmer air is not the essential condition of storm-formation: "Storms sometimes originate along the eastern Rocky Mountain slope when the temperature of the air is lower there than in any part of the United States (for an example see the Signal Service charts of Jan. 19 and 20, 1886), and storms appear to orginate in this region as often in the night as in the day."

Very recently Hann has investigated the temperature observations at numerous stations in the Alps during the passage of several cyclones (*Meteorologische Zeitschrift*, September, 1890), and has concluded that the temperature of the air-column as a whole is lower in cyclones than that of the surrounding air. Hann's investigations may not be conclusive for reasons stated by Ferrel, but they certainly add a link to the chain of evidence.

As a result of their investigations, Loomis and Hann both decided that cyclones were largely the result of mechanical causes. Loomis concluded that they were originated by the conflicting winds between two or more anticyclones, and Hann suggests that they are whirls originating in the upper air.

Now, I think Ferrel, in his recent letter to *Science*, unintentionally did Davis an injustice by suggesting that Davis had suddenly altered his opinion merely because Hann advanced these views. Davis has for years been the leading exponent in this country of the dynamical heating of the air in anticyclones, and during recent years I have several times spoken with him about the mechanical origin of cyclones; and, if he is now inclined to give these views more weight, it is because this last link in the chain of evidence has convinced him of the necessity of reconsidering the condensation theory.

I have for several years been convinced that mechanical action had much to do with the origin and development of cyclones, and as working hypotheses in making weather-predictions have carefully watched the following conditions as favorable for the production of cyclones: 1. The central region between approaching anticyclones. 2. The region where lower air-currents set in nearly opposed in direction to upper air-currents, so as to favor the production of a whirl. This latter condition is most frequently brought about in the United States when colder winds, moving from the north-west near the earth's surface, set in to the south or south-west of an area of high temperature or very high pressure, which give rise to upper currents moving from the south. This was the condition preceding the origin of the very violent storm of March 12, 1888. 3. The deflection of air-currents by a long, tall range of mountains, such as the Rockies. I have several times predicted the origin of cyclones under these conditions. One of these was on April 19, 1883.

I have found the following conditions favorable to the increase of energy in cyclones: 1. The meeting of cyclones moving from nearly opposite directions; 2. The closing-up of a long trough of low pressure by the pressure increasing at both ends; 3. Cyclones, being mainly controlled in their movements by upper air-currents, are sometimes carried by these toward areas of denser air near the earth's surface, and under these conditions tend to increase in energy. Examples of violent storms, developed, as I think, by these mechanical methods, will be found on the following dates: Oct. 14, 1886; Jan. 9, 1889; and Jan. 9, 1886.

The immense gain that would come from being able to anticipate this class of storms may be inferred from the fact that not one of those I have mentioned in this paper was heralded by our Weather Service in time to be of any use, though the amount of damage done was enormous.

The views I hold are, that differences of pressure result from differences of temperature over immense areas, as between equator and pole, ocean and continent. This distribution of pressure is modified by the effect of the earth's rotation, and is continuously varying with the changes in temperature of the air.

The smaller cyclones and anticyclones of our weather-maps are partly or chiefly brought about by the mechanical action of counter-currents in the manner previously explained, though greatly modified by local differences of temperature and density within the cyclone: in other words, they are caused by forces originating outside their field of origin instead of within it, as supposed by Ferrel.

General rains are chiefly the result, and not the cause, of ascending currents of air. Differences of pressure in the upper air have a very important bearing on the origin and development of cyclones. Well-defined areas of low pressure, accompanied by precipitation and an inward tendency of the upper wind, occasionally exist in the upper atmosphere without being indicated by the barometric pressure at the earth's surface.

I have held most of these views for several years, as will be found by my review of Loomis in the *American Meteorological Journal*, and by two articles in *Nature* on the origin of anticyclones, and the cause of precipitation (*Nature*, vol. xxxvi. 1887, and vol. xxxviii. July, 1888), and have hoped to make some quantitative estimates of the forces and supposed causes; but I have not had the time, and fear I have not the ability to do so.

I trust Professor Ferrel will not dismiss these as vague hypotheses unworthy of notice, but will tell us (1) whether the method suggested by Loomis is insufficient to generate a cyclonic whirl according to mechanical principles; (2) whether conflicting air-currents can be supposed to have sufficient inertia to aid in producing a whirl, as, for instance, when denser air sets rapidly inward from both ends of a long trough of low pressure; and (3) whether such cyclones as that of Jan. 20, 1886, which originated near the longitude of Denver, where the temperature was lower than in any other part of the United States, when the observations on Pike's Peak showed no vertical decrease at all between the summit and base of the mountain, and when there was no appreciable precipitation within a thousand miles of the place of origin, could be explained by any reasonable assumption of a higher mean temperature of the air-column within the field of the cyclone.

H. HELM CLAYTON.

Blue Hill Observatory, Dec. 29.

BOOK-REVIEWS.

Handbook of Problems in Direct Fire. By JAMES M. INGALLS. New York, Wiley. 8°. $4.

THIS book, which is believed to be the first of its kind ever published, shows the close attention now given to what may be called the scientific side of modern warfare, or, rather, of preparation for war. It is devoted wholly to problems in gunnery involving the use of ordinary service charges of powder and angles of elevation for the guns not exceeding 15°, which is the definition of

"direct fire." The author of the book, Capt. Ingalls of the First Regiment United States Artillery, instructor of ballistics at the United States Artillery School, has already given to the public two works on the same subject,—"Exterior Ballistics," and "Ballistic Machines." This work was prepared while the author was engaged in teaching ballistics to student officers at the artillery school at Fort Monroe, and most of the examples are such as were given out from time to time to classes under his instruction, as exercises in ballastic formulæ. It will prove to be of permanent value, not only to the particular branch of the service for which it was intended, but also for other branches, both regular and militia. The most important of the examples may be worked out with a very slight knowledge of mathematics, arithmetic and a little algrebra being sufficient for many of them.

AMONG THE PUBLISHERS.

IN *Lippincott's Magazine* for January, 1891, we note "The State of Washington," an article by Major Moses P. Handy, which will surprise the many who know little of this section of the country; and "The Road Movement," an article by Lewis M. Haupt, C.E., which contains some suggestions for the much-needed improvement of public roads.

— Messrs. Houghton, Mifflin, & Co. announce a new edition of Mr. Lowell's "Fable for Critics." This poem, in which all the prominent American authors of the period at which it was written are reviewed with keen appreciation mingled with good-natured banter, Mr. Lowell composed when he was under thirty years of age. "This *jeu d'esprit*," says Mr. Lowell in a prefatory note, "was extemporized, I may fairly say, so rapidly was it written, purely for my own amusement, and with no thought of publication. I sent daily instalments of it to a friend in New York, the late Charles F. Briggs. He urged me to let it be printed, and I at last consented to its anonymous publication. The secret was kept till after several persons had laid claim to its authorship." There are twenty-six authors mentioned in the poem, and the publishers have made the book more interesting by securing portraits of each of these writers, taken about the time the original edition was published. These are reproduced in outline, and are inserted in the text at the point where each author is mentioned. A list of the authors alluded to is also given for the first time, so that the surmises to which the fable has always given rise will at last be set at rest.

— The first number of *The Bacteriological World*, edited by P. Paquin, M.D., Columbia, Mo., has appeared.

—A paper on the "Echinoderms from the Northern Coast of Yucatan and the Harbor of Vera Cruz," by J. E. Ives, assistant to the curator in charge of the Academy of Natural Sciences of Philadelphia, is published in the "Proceedings of the Academy of Natural Sciences of Philadelphia," Sept. 30, 1890. The *Echinodermata* which form the subject of this paper were collected on the northern coast of Yucatan and at Vera Cruz, in the spring of the present year, by an expedition from the Academy of Natural Sciences of Philadelphia to investigate the natural history of Yucatan and Mexico. The results in this department are interesting. One new genus and three new species are described, a little-known species is figured for the first time, the synonymy of this species and of some others has been studied with profitable results, and the majority of the species collected supply new localities which form connecting points between the northern and southern portions of the great West Indian, or eastern tropical American littoral fauna. The northern coast of Yucatan possesses a sandy beach largely made up of shell fragments. The water off the coast is very shallow, the ten-fathom line being twenty miles from the shore, and the hundred-fathom line about one hundred and fifty miles. Three miles off the shore in the neighborhood of Progreso, the bottom is of a sandy character, although